

THE ROYAL CANADIAN INSTITUTE

November 1953

Botanical Series

Vol. XII, No. 1

# Memoirs of the Department of Agriculture in India

THE WHEATS OF BIHAR AND ORISSA

BY

ALBERT HOWARD, C.I.E., M.A.  
*Imperial Economic Botanist*

GABRIELLE L. C. HOWARD, M.A.  
*Second Imperial Economic Botanist*

AND

ABDUR RAHMAN KHAN  
*Second Assistant to the Imperial Economic Botanist*



AGRICULTURAL RESEARCH INSTITUTE, PUSA

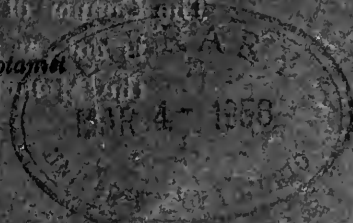
PRINTED AND PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA  
W. THACKER & CO., 2, CRESS LANE, LONDON

Price, 2s. 6d. or 3s.



EDITED BY

The Council of the Pusa Agricultural Research Institute which  
is not, as a body, responsible for the opinions expressed in  
the Memoir.

# MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

BOTANICAL SERIES

Volume XII



AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR  
THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY  
THACKER, SPINK & CO., CALCUTTA  
W. THACKER & CO., 2, CREED LANE, LONDON

EDITED BY

The Council of the Pusa Agricultural Research Institute,  
which is not, as a body, responsible for the opinions  
expressed in these Memoirs.

# CONTENTS

## Volume XII

	PAGE
No. 1. HOWARD, ALBERT ; HOWARD, GABRIELLE L. C. ; and ABDUR RAHMAN KHAN. The Wheats of Bihar and Orissa ..	1
No. 2. McRAE, W. I. History of the Operations against Bud-Rot of Palms in South India. II. Inoculation Experiments with <i>Phytophthora palmivora</i> Butl. on <i>Borassus flabellifer</i> Linn. and <i>Cocos nucifera</i> Linn. (with one text-figure and two plates, of which one coloured) .. .. .	21
No. 3. KOTTUR, G. L. Studies in Inheritance in Cotton, I. History of a Cross between <i>Gossypium herbaceum</i> and <i>Gossypium neglectum</i> (with seven text-figures and one plate) .. .. .	71
No. 4. HOWARD, GABRIELLE L. C. ; and ABDUR RAHMAN KHAN. Studies in Indian Oil Seeds, No. 2. Linseed (with one text-figure and three plates, of which two coloured) ..	135
No. 5. PATEL, MAGANLAL L. Studies in Gujarat Cottons, Part II (with nine text-figures and three plates) .. .. .	185



November 1922

BOTANICAL SERIES

Vol. XII, No. 1

# MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

## THE WHEATS OF BIHAR AND ORISSA

BY

ALBERT HOWARD, C.I.E., M.A

*Imperial Economic Botanist*

GABRIELLE L. C. HOWARD, M.A

*Second Imperial Economic Botanist*

AND

ABDUR RAHMAN KHAN

*Second Assistant to the Imperial Economic Botanist*



AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR

*THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA*

BY

THACKER, SPINK & CO., CALCUTTA

W. THACKER & CO., 2 CREED LANE, LONDON

# Agents for the Sale of Government Publications

## IN THE UNITED KINGDOM

- |   |   |
|---|---|
| Constable & Co., 10, Orange Street, Leicester Square, London, W.C.                                  | W. Thacker & Co., 2, Creed Lane, London, E.C.         |
| Kegan Paul, Trench Trübner & Co., 68-74, Carter Lane, E.C., and 39, New Oxford Street, London, W.C. | Luzac & Co., 46, Great Russell Street, London, W.C.   |
| Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.                                   | Wheldon & Wesley, Ltd., 28, Essex Street London, W.C. |
| P. S. King & Sons, 2 and 4, Great Smith Street, Westminster, London, S.W.                           | B. H. Blackwell, 50 and 51, Broad Street Oxford.      |
| H. S. King & Co., 65, Cornhill, E.C., and Pall Mall, London, W.                                     | Deighton, Bell & Co., Ltd., Cambridge.                |
| Grindlay & Co., 54, Parliament Street, London, S.W.   | Oliver & Boyd, Tweedale Court, Edinburgh.             |
| T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.   | E. Ponsonby, Ltd., 116, Grafton Street, Dublin.       |

## ON THE CONTINENT

- |  |                               |
|--|-------------------------------|
| Ernest Leroux, 28, Rue Bonaparte, Paris. | Otto Harrassowitz, Leipzig.   |
| Martinus Nijhoff, The Hague, Holland.    | Friedlander and Sohn, Berlin. |

## IN INDIA AND CEYLON

- |  |  |
|--|--|
| <b>Thacker, Spink &amp; Co.,</b> Calcutta and Simla.                                       | D. B. Taraporevala, Son & Co., Bombay.   |
| W. Newman & Co., Calcutta.   | Radhabai Atmaram Sagoon, Bombay.   |
| R. Cambray & Co., Calcutta.  | Sunder Pandurang, Bombay.  |
| S. K. Lahiri & Co., Calcutta.  | Gopal Narayan & Co., Bombay.   |
| B. Banerjee & Co., Calcutta.   | Ramchandra Govind & Son, Kalbadevi Bombay.                                     |
| The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca. | Proprietor, New Kitabkhana, Poona.   |
| Butterworth & Co. (India), Limited, Calcutta.  | The Standard Bookstall, Karachi.   |
| The Weldon Library, 18-5, Chowringhee Road, Calcutta.                                      | Mangaldas Harkisandas, Surat.  |
| Rai M. C. Sircar Bahadur and Sons, 75-1-1, Harrison Road, Calcutta.                        | Karsandas Narandas & Sons, Surat.  |
| Standard Literature Co., Ltd., Calcutta.   | A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.                           |
| Lal Chand and Sons, Calcutta.  | N. B. Mathur, Superintendent, Nazir Kanun i Hind Press, Allahabad.             |
| Association Press, Calcutta.   | Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depôt, Juhu, Cawnpore. |
| Higginbothams, Ltd., Madras.   | Rama Krishana and Sons, Lahore.  |
| V. Kalyanarama Iyer & Co., Madras.   | Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore.                     |
| G. A. Natesan & Co., Madras.   | Superintendent, American Baptist Mission Press, Rangoon.                       |
| S. Murthy & Co., Madras.   | Manager the "Hitavada," Nagpur.  |
| Thompson & Co., Madras.  | S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.                 |
| Temple & Co., Madras.  | A. M. & J. Ferguson, Colombo, Ceylon.  |
| P. R. Rama Iyer & Co., Madras.   |  |
| Vas & Co., Madras.   |  |
| E. M. Gopalkrishna Kone, Madras.   |  |
| Thacker & Co., Ltd., Bombay.   |  |



# THE WHEATS OF BIHAR AND ORISSA.

BY

ALBERT HOWARD, C.I.E., M.A.,

*Imperial Economic Botanist,*

GABRIELLE L. C. HOWARD, M.A.,

*Second Imperial Economic Botanist,*

AND

ABDUR RAHMAN KHAN,

*Second Assistant to the Imperial Economic Botanist.*

[Received for publication on June 12, 1922.]

## I. INTRODUCTION.

SINCE the publication of the botanical classification<sup>1</sup> of the wheats of Bengal, a new Indian Province, Bihar and Orissa, has been created. In this administrative area are to be found practically the whole of the wheat growing tracts of old Bengal. The wheats of Bengal have become to a large extent the wheats of Bihar and Orissa.

The preliminary classification, published in 1909, was only carried as far as the botanical variety. Since that time, the various agricultural types (unit species) which make up these varieties have been grown for some years in pure culture at Pusa and have been studied in considerable detail. The present paper deals with 122 of these agricultural types of common wheat (*Triticum vulgare* Vill.) belonging to twelve botanical varieties, three of which do not appear to have been described.

<sup>1</sup> *Wheat in India*, 1909, p. 196.

The material from which these 122 agricultural types were obtained was collected at harvest time mainly from cultivators' fields in the most important wheat growing tracts of Bihar, north and south of the Ganges. The ripe ears were first classified according to the botanical variety and were then sown separately, side by side, for several years. As soon as sufficient seed was obtained for sowing small plots (about 10 feet wide and 30 feet long), it was noticed that the finer characters (such as the time of coming into ear, the characters of the ears and leaves at the time of flowering, the power of tillering, the vegetative vigour at the time of pollination, the resistance to rust and the length and strength of straw) became much more definite and distinct than when the cultures were grown in single lines next to next. What may be termed the massed habit came into operation the moment the cultures were grown in oblong plots. In the early morning, when the plants are fully turgid and when the foliage and ears are illuminated by the slanting rays of the sun, differences which cannot be detected a few hours later stand out clearly. Equally definite is the behaviour of the cultures towards the three rusts<sup>1</sup> which occur at Pusa. In the same botanical variety, agricultural types occurred which differed more in their degree of susceptibility to rust than in any other character. In several instances, two types—almost identical in field characters—exhibited great differences in resistance to brown rust (*Puccinia triticina* Eriks.).

By taking advantage of the time of ripening, of the vegetative characters at the time of flowering and of the degree of resistance to the various rusts, it is not difficult to classify the unit species within the botanical variety even when the number of these types is very great. While the finer differences, such as the tone of colour of the leaves and of the ears at the time of pollination, are inherited exactly like the more important botanical characters (the presence or absence of awns, colour of the chaff and grain), nevertheless the degree of their expression depends on the way the crop is grown and also on the season. If no particular care is taken in raising the cultures and if the season is adverse, the fine vegetative differences do not stand out sharply and types really different in the field can then only be distinguished by the degree of their resistance to brown, yellow or black rust.

Ordinarily, systematic botany deals with nothing below the variety and does not recognize the differences between the unit species which make up these varieties. While such a point of view is obviously essential in dealing with herbarium specimens and with the large groups of plants belonging to genera

<sup>1</sup> The three species of rust which attack wheat at Pusa, in the order of their appearance, are: brown rust (*Puccinia triticina* Eriks.), yellow rust (*P. glumarum* Eriks. & Henn.), and black rust (*Puccinia graminis* Pers.).

and orders, it does not go far enough for the plant breeder who has to study the elementary species themselves in the field from sowing time to harvest and to ascertain their potentialities as parents or as the starting point in schemes of seed distribution. By employing the methods of the systematist, however, it is possible to classify and to distinguish clearly the unit species which make up the variety. Such an exercise is an essential preliminary in the study of cultivated crops, in the methods of selection and also in the creation of new forms by hybridization. It is mainly to emphasize the importance of systematic botany in the training of the plant breeders of the future that we have recorded this classification of the unit species which compose the varieties of the common wheats met with in Bihar. Such a collection of unit species serves a double purpose. In the first place, they are of the greatest use in bringing home to the student the great complexity of the Linnean species and the vast amount of preliminary work which is essential in every crop before research proper can be undertaken with any hope of success. In the second place, they form the raw material for the plant breeder and the mycologist and so their proper maintenance becomes an important part of the work of research institutes which deal with crops.

As the intensive study of cultivated plants develops all over the world, an increasing amount of accurate information on the composition of the botanical variety will become available. The work already published indicates that the number of different unit species in existence in each botanical variety is certain to be very great and may, in some cases, run into hundreds.<sup>1</sup> It is important from the point of view of the future of plant breeding that these unit species should be maintained and that the material should be readily available to workers in all countries. It is only in this way that the vast possibilities in the improvement of cultivated crops can be realized. Perhaps the easiest method of maintaining these collections will be for the Central Research Institutes, maintained by Government in the various countries, to undertake the work and for each to concentrate on a few important corps. In this way a beginning could be made in the ultimate classification of cultivated plants with the resources now available. If, as is likely, the free interchange of unit species proves to be of importance in the rapid production of improved seed for general distribution, the extension of this work will then be only a question of time and of mutual arrangement among the workers themselves.

<sup>1</sup> That many of the varieties of common wheat, *Triticum vulgare* Vill., comprise a very large number of unit species is indicated by the work of Vavilov and his colleagues in Russia. The details of this work are in the press but the general results are summed up in a paper on the law of homologous series in variation in the *Jour. of Genetics*, XII, 1922, p. 47.

## II. CLASSIFICATION OF THE WHEATS OF BIHAR AND ORISSA.

The wheats of Bihar are characterized by weak straw, poor vegetative growth and early maturity. Almost all are bearded with smooth chaff and short, rounded grains. Three of the varieties possess blackish chaff on a red or white ground with black awns. In the size and shape of the grain and in the frequent occurrence of black awns, these wheats are sharply distinguished from the types met with in the United Provinces and the Punjab. Among Indian wheats they most closely resemble the forms often found in the Himalayas and on the Western Frontier. Some of the types are very resistant to brown, yellow and black rusts, particularly those belonging to the new variety *nigricans*. High grain quality, comparable with that of Manitoba wheats, also occurs among these types as is shown by the results of the milling and baking tests<sup>1</sup> carried out in 1909 by Mr. A. E. Humphries. So far as we have investigated the matter, some of these wheats appear to possess greater strength than any of the other indigenous types we have examined. It is easy to understand that in a damp climate such as that of Bihar which favours rust epidemics, natural selection would operate in eliminating types susceptible to disease and in preserving the more resistant forms. The occurrence of stronger wheats in this tract than in the rest of the plains is, however, not so easily explained. None of the types are likely to prove of use for distribution to the cultivators on account of their weak vegetative characters and their inability successfully to respond to intensive cultivation. They may, however, prove to be of the very greatest use in plant breeding in providing early maturing parents with great resistance to rust combined with short straw and grain qualities above the average. It is possible that one of these unit species has already been made use of in the production of an improved wheat. Marquis<sup>2</sup>, the celebrated Canadian variety, which covers millions of acres in North America, was obtained by crossing Red Fife with one of the wheats found in Hard Red Calcutta. This is the most successful wheat variety hitherto evolved by the plant breeder.

In the classification of the varieties we have followed the system devised by Koernicke with the addition of three new varieties with blackish chaff and black awns not included in *Die Arten und Varietäten des Getreides* or in the subsequent literature on this subject. As far as our investigations have gone, these new varieties are only met with in Bihar and Orissa.

In distinguishing the unit species which constitute the varieties, we have made full use of all the vegetative characters at the time of pollination. The

<sup>1</sup> Bulletin 17, Agri. Research Institute, Pusa, 1910, p. 9.

Buller, A. H. R. *Essays on wheat*, New York, 1919.

time of coming into ear enables the types to be divided into classes such as very early, early, intermediate, late and very late. The length of the straw when pollination is completed serves to distinguish short, intermediate and tall forms. The tone of colour of the ears and of the foliage together with the presence or absence of bloom are most useful characters at the time of flowering as well as the length and breadth of the leaves and the manner in which they are disposed (vertical or drooping). From the time of flowering to harvest, the types often differ markedly in the amount of leaf rust. The numbers for stem rust as well as the standing power of the types can best be distinguished at harvest time. The period when it is easiest to distinguish the unit species is, however, during the time when the flowers are fertilized at the end of the vegetative period.

In order to record from year to year the degree of susceptibility of the various unit species to the three common rusts, we have employed Eriksson's notation in which the increasing amount of infection is represented by the numbers 1, 2, 3 and 4. When traces only of rust could be found with difficulty, this is indicated by the words *slight* or *very slight*. The entire absence of any rust is indicated by the symbol zero.

The records of rust-resistance vary to some extent from year to year. This is inevitable on account of the natural incidence of the many factors on which an epidemic depends. Besides the inherent resistance of the unit species themselves and the well known influence of such factors as humidity and temperature on the spread of the fungus, the various external factors also affect the resistance of the host. A time comes when conditions are optimum for the rust and when the resistance of the host is near its lowest point. Maximum rust numbers are then obtained. If the season favours the host, lower numbers are likely to be the rule. There is, however, a further complication, namely, the period in the life-history of the host when the rust attack takes place. When this occurs before the ripening process begins, the rust has time to accomplish the maximum amount of damage. If the attack takes place very late in the season when ripening is nearly completed, the crop may be only slightly affected. As a collection of unit species contains very early, early, late and very late types, it is easy to see that in certain years some of the groups are favoured while others are severely handicapped. As a rule, the early types tend to escape while the late ones are the most seriously affected. These considerations explain why the numbers for any particular rust vary from year to year and why it is necessary to keep under close observation for some years any types which appear to be more resistant than the average. It is only when a particular unit species escapes rust

almost entirely for a series of years that we can say with any confidence that it is really rust resistant. As an example of the kind of influence which the season exerts on the degree of infection, the black rust numbers obtained at Pusa in two seasons in the case of two groups of unit species (one rust resistant, the other susceptible) may be quoted.

TABLE I.  
*Seasonal variation in resistance to black rust.*

(a) *var. nigricans* (resistant).

Type num- btr	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1916	1	1	1	1	1	1	v.s.	1	v.s.	1	1	1	1	v.s.	v.s.	1	2	v.s.	1	1
1921	s.	1	s.	1	1	1	s.	1	v.s.	1	0	s.	1	1	1	1	s.	1	s.	1

v.s. = very slight.

s. = slight.

0 = black rust absent.

(b) *var. græcum* Keke. (susceptible).

Type number	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1915	3	2	2	3	3	3	2	4	2	3	3	3	3	3	1	2	3
1921	2	1	1	1	2	1	2	2	1	2	1	2	2	2	2	2	3

#### TRITICUM VULGARE VILL. COMMON WHEATS.

Ears bearded or beardless; outer glumes not keeled to the base; straw hollow; grain neither very long nor round.

##### I. Ears beardless (short tips).

##### 1. Glumes smooth.

##### A. Glumes white.

##### (a) Grain white.

var. *albidum* Al.

Types 1-4.

##### (b) Grain red.

var. *lutescens* Al.

Type 5.

## B. Glumes red.

## (a) Grain white.

var. *alborubrum* Kcke.

Types 6-9.

## (b) Grain red.

var. *millurum* Al.

Types 10-12.

## II. Ears bearded.

## 1. Glumes smooth.

## A. Glumes white.

## (a) Grain white.

var. *græcum* Kcke.

Types 13-29.

## (b) Grain red.

var. *erythrospermum* Kcke.

Types 30-57.

## B. Glumes red.

## (a) Grain white.

var. *erythroleucon* Kcke.

Types 58-71.

## (b) Grain red.

var. *ferrugineum* Al.

Types 72-80.

## C. Glumes black on a white ground, awns black.

## (a) Grain red.

var. *nigricans*.

Types 81-100.

## D. Glumes black on a red ground, awns black.

## (a) Grain white.

var. *indicum*.

Types 101-109.

## (b) Grain red.

var. *bengalensis*.

Types 110-121.

## 2. Glumes felted.

## A. Glumes white.

## (a) Grain white.

var. *meridonale* Kcke.

Type 122.

In the above scheme, the distinction between bearded and beardless wheats is the one in common use. In reality, however, true beardless wheats possess no awns of any kind while there are at least two different kinds of tips which are commonly grouped among the beardless forms. These we have described in a previous paper<sup>1</sup> as *short tips* and *long tips*. When these are crossed, bearded, intermediates and true beardless are produced in the 9 : 3 : 3 : 1 ratio. Strictly speaking, the so-called beardless wheats will have to be broken up into at least three classes and the ordinary schemes of classification will have to be revised. The beardless wheats of Bihar all appear to possess short tips. Complete proof of this point can, however, only be obtained by employing these unit species as parents.

#### DESCRIPTION OF UNIT SPECIES.

##### var. *albidum* Al.

Ears beardless (short tips), glumes smooth white, grain white.

This variety is represented by four agricultural types all of which are susceptible to rust and are characterized by weak straw. The critical observations on the field characters and on the incidence of rust were made in 1915.

##### 1. Early.

- No. 1. Intermediate in height ; ears very light green ; leaves somewhat drooping, light green. Brown rust 3, yellow rust 4, black rust 3. Straw very weak.

##### 2. Late.

- No. 2. Short ; ears dark green with much bloom ; leaves erect, dark green. Brown rust 3, yellow rust 3, black rust 3. Straw weak.
- No. 3. Short ; ears dark green with much bloom ; leaves erect, dark green. Brown rust 3, yellow rust 2, black rust 1. Straw very weak.
- No. 4. Short, tillers well ; ears dark green with much bloom ; leaves erect, dark green. Brown rust 2, yellow rust 1, black rust 1. Straw weak.

##### var. *lutescens* Al.

Ears beardless (short tips), glumes smooth white, grain red.

This variety is represented by a single agricultural type which is characterized by susceptibility to rust and by rather weak straw.

- No. 5. Somewhat early, short ; ears dark green with a bluish tinge and much bloom ; leaves erect, somewhat dark green. Brown rust 3, yellow rust 3, black rust 2. Straw rather weak.

<sup>1</sup>Mem. of the Dept. of Agri. in India (Botanical Series), Vol. VII, 1915, p. 273.



*var. alborubrum* Keke.

Ears beardless (short tips), glumes smooth red, grain white.

This variety is represented by four agricultural types which fall into three groups according to the time of maturity. With one exception (No. 6), all are characterized by susceptibility to rust and by very weak straw. One of the original pure line cultures was rejected on account of uneven growth following natural cross-fertilization. The observations on which the classification is drawn up were made in 1915.

1. Early.

No. 6. Tall, vigorous; ears very light bright green; leaves drooping, light green. Brown rust 2, yellow rust 1, black rust 1. Straw very weak.

No. 7. Tall, vigorous; ears light green with much bloom; leaves drooping, light green. Brown rust 2, yellow rust 2, black rust 2. Straw very weak.

2. Intermediate in time of maturity.

No. 8. Tall; ears somewhat light green with much bloom; leaves slightly drooping, somewhat light green. Brown rust 3, yellow rust 2, black rust 1. Straw very weak.

3. Late.

No. 9. Intermediate in height; ears dark green with moderate bloom; leaves broad, erect, dark green. Brown rust 3, yellow rust 3, black rust 2. Straw very weak.

*var. milturum* Al.

Ears beardless (short tips), glumes smooth red, grain red.

This variety is represented by three agricultural types which differ considerably in time of maturity. They are all characterized by susceptibility to rust attack and weak straw.

1. Early.

No. 10. Tall, vigorous; ears light green with much bloom; leaves erect, dark green. Brown rust 3, yellow rust 3, black rust 3. Straw very weak.

2. Intermediate in time of maturity.

No. 11. Intermediate in height; ears dark green with moderate bloom; leaves erect, dark green. Brown rust 3, yellow rust 2, black rust 3. Straw very weak.

## 3. Late.

No. 12. Intermediate in height; ears dark green with moderate bloom; leaves erect, dark bluish green. Brown rust 3, yellow rust 2, black rust 3. Straw weak.

var. *gracum* Kcke.

Ears bearded, glumes smooth white, grain white.

This variety is represented by seventeen agricultural types which fall into three groups according to the time of maturity. The observations on which the classification is based were made in 1915.

## 1. Early.

No. 13. Very early, short weak; ears dull green; leaves narrow and very drooping, somewhat light bluish green with much bloom. Brown rust 2, yellow rust 4, black rust 3. Straw very weak.

No. 14. Intermediate in height, vigorous; ears dull green; leaves erect, broad, medium green with moderate bloom. Brown rust 4, yellow rust 3, black rust 2. Straw very weak.

No. 15. Intermediate in height, weak; ears dull green; leaves erect, broad, somewhat light green with moderate bloom. Brown rust 3, yellow rust 3, black rust 2. Straw very weak.

Nos. 14 and 15 are nearly alike in the field but are not identical. No. 14 is more vigorous and has darker foliage than No. 15 and is more susceptible to brown rust.

No. 16. Intermediate in height, vigorous; ears light green; leaves slightly drooping, light green with much bloom. Brown rust 3, yellow rust 2, black rust 3. Straw very weak.

## 2. Intermediate in maturity.

No. 17. Intermediate in height, weak; ears light green; leaves slightly drooping, dark green with much bloom. Brown rust 3, yellow rust 4, black rust 3. Straw very weak.

No. 18. Intermediate in height; ears light green; leaves erect, light green, with slight bloom. Brown rust 2, yellow rust 2, black rust 3. Straw weak.

No. 19. Tall, vigorous; ears light green; leaves slightly drooping, light green with very little bloom. Brown rust 1, yellow rust 1, black rust 2. Straw weak.

No. 20. Tall, vigorous; ears light green; leaves broad, slightly drooping, dark green with moderate bloom. Brown rust 1, yellow rust 1, black rust 4. Straw weak.

- No. 21. Very tall ; ears somewhat dark green ; leaves erect, dark green with much bloom. Brown rust 3, yellow rust 1, black rust 2. Straw fairly strong. This culture, as regards the colour of the green ears, forms a connecting link with the next four types (Nos. 22, 23, 24 and 25).
- No. 22. Tall, weak ; ears dark green ; leaves drooping, somewhat dark green with much bloom. Brown rust 4, yellow rust 3, black rust 3. Straw very weak.
- No. 23. Tall, weak ; ears dark green ; leaves drooping, light green with much bloom. Brown rust 3, yellow rust 3, black rust 3. Straw very weak.
- No. 24. Tall, vigorous ; ears dark green ; leaves slightly drooping, somewhat light green with much bloom. Brown rust 2, yellow rust 3, black rust 3. Straw very weak.
- No. 25. Tall, vigorous ; ears dark green ; leaves drooping, dark green with much bloom. Brown rust 4, yellow rust 4, black rust 3. Straw very weak.
3. Late (the four cultures ripen in the following order—29, 26, 28, 27).
- No. 26. Tall, very late ; ears somewhat dark green ; leaves erect, somewhat dark green with much bloom. Brown rust 2, yellow rust 3, black rust 3. Straw weak.
- No. 27. Tall ; ears light green, leaves somewhat light green with slight bloom. Brown rust 1, yellow rust 1, black rust 1. Straw fairly strong.
- No. 28. Tall ; ears very light green ; leaves erect, somewhat light green with very slight bloom. Brown rust 2, yellow rust 1, black rust 2. Straw somewhat weak.
- No. 29. Tall ; ears light green ; leaves erect (more so than 28), dark green with very slight bloom. Brown rust 2, yellow rust 1, black rust 3. Straw fairly strong.
- Nos. 28 and 29 are nearly alike and differ only in the colour of the ears, in the colour and set of the leaves, in resistance to black rust and in time of maturity.

var. *erythrospermum* Kcke.

Ears bearded, glumes smooth white, grain red.

This variety comprises twenty-eight agricultural types which fall into four classes according to time of maturity. The observations on which this classification is based were made in 1916.

## 1. Very early.

No. 30. Intermediate in height, strong ; ears very light bright green ; leaves drooping, light green. Brown rust 1, black rust 2. Straw weak.

No. 31. Short ; ears dull light green ; leaves erect, dark green. Brown rust 4, black rust 4. Straw weak.

No. 32. Short, rather weak ; ears dull dark green ; leaves erect, dark green. Brown rust 3, black rust 4. Straw weak.

No. 33. Short, weak ; ears dark green ; leaves erect, dark green. Brown rust 4, black rust 4. Straw weak.

Nos. 32 and 33 closely resemble each other in the field but are not identical. No. 32 is slightly taller and more resistant to brown rust than No. 33 and also has lighter ears than No. 33.

## 2. Early.

No. 34. Tall ; ears somewhat dull light green ; leaves erect, light green. Brown rust 1, black rust 2. Straw weak.

No. 35. Tall ; ears somewhat dull light green ; leaves erect, broad, somewhat light green. Brown rust 1, black rust 2. Straw weak.

No. 36. Intermediate in height, vigorous ; ears light bright green ; leaves erect, very dark green. Brown rust 1, black rust 2. Straw fairly strong.

No. 37. Tall ; ears light green (lighter than No. 38) ripening to a bright tone ; leaves erect, broad, dark green. Brown rust 1, black rust 2. Straw weak.

No. 38. Tall ; ears light green (darker than No. 37) ripening to a dull tone ; leaves erect, broad, dark green. Brown rust 0, black rust 2. Straw somewhat weak.

Nos. 37 and 38 closely resemble each other and only differ in the tone of colour of the ripe ears, in the strength of straw and in resistance to brown rust. Nos. 34, 35, 36, 37 and 38 are all tall and form a natural subdivision of the early types.

No. 39. Intermediate in height, weak ; ears dull dark green ; leaves erect, light green. Brown rust 1, black rust 3. Straw weak.

No. 40. Tall, weak ; ears dull dark green ; leaves erect, somewhat light green. Brown rust 1, black rust 3. Straw weak.

No. 41. Tall, weak ; ears light green, ripening to a dull tone ; leaves erect, very light green (lighter than No. 39). Brown rust 1, black rust 3. Straw weak.

No. 42. Short, weak ; ears dull dark green ; leaves erect, dark green.  
Brown rust 2, black rust 3. Straw weak.

No. 43. Short, weak ; ears dull dark green ; leaves somewhat light green. Brown rust 3, black rust 4. Straw weak.

No. 44. Short ; ears somewhat light green, ripening to a dull tone ; leaves erect, somewhat light green. Brown rust 1, black rust 3. Straw weak.

No. 45. Intermediate in height, weak ; ears dark green, ripening to a dull tone ; leaves erect, dark green. Brown rust 1, black rust 4. Straw weak.

3. Late.

No. 46. Intermediate in height, strong ; ears dark green, ripening to a somewhat bright tone ; leaves erect, broad, dark green. Brown rust 1, black rust 2. Straw fairly strong.

No. 47. Intermediate in height, strong ; ears somewhat light bright green ; leaves erect, dark green. Brown rust 0, black rust slight. Straw strong.

No. 48. Intermediate in height ; ears dark green ripening to a dull tone ; leaves erect, somewhat light green. Brown rust 2, black rust 4. Straw very weak.

No. 49. Intermediate in height ; ears dark bluish green ripening to a dull tone ; leaves erect, dark bluish green. Brown rust 0, black rust 2. Straw fairly strong.

No. 50. Intermediate in height, somewhat weak ; ears dull dark green ; leaves erect, somewhat light green. Brown rust 1, black rust 3. Straw very weak.

No. 51. Intermediate in height, somewhat weak ; ears somewhat light green ; leaves erect, dark green. Brown rust 1, black rust 2. Straw strong.

No. 52. Intermediate in height, weak ; ears dull dark green ; leaves erect, somewhat dark green. Brown rust 0, black rust 2. Straw strong.

4. Very late.

No. 53. Short ; ears somewhat light bright green ; leaves erect, very dark green. Brown rust 1, black rust 2. Straw somewhat weak.

No. 54. Intermediate in height ; ears dark green ; leaves erect, dark bluish green. Brown rust 2, yellow rust 1, black rust 4. Straw weak.

- No. 55. Intermediate in height, tillers well ; ears light bright green ; leaves erect, very dark green. Brown rust 0, black rust 2. Straw strong.
- No. 56. Intermediate in height, very weak ; ears dull dark green ; leaves erect, somewhat light bluish green. Brown rust 1, black rust 3. Straw weak.
- No. 57. Tall, strong ; ears rather dark green ripening to a dull tone ; leaves erect, very dark green. Brown rust 0, black rust slight. Straw strong.

*var. erythroleucon* Kcke.

Ears bearded, glumes smooth red, grain white.

This variety comprises fourteen agricultural types which fall into three groups according to maturity. One culture was rejected on account of want of uniformity arising from natural cross-fertilization. The field observations on which the classification is based were made in 1915.

1. Early.

- No. 58. Intermediate in height, weak ; ears dark bright green ; leaves broad, drooping, dark green with moderate bloom. Brown rust 3, yellow rust 3, black rust 2. Straw very weak.
- No. 59. Tall, vigorous ; ears bright dark green ; leaves erect, dark green (darker than No. 60) with moderate bloom. Brown rust 3, yellow rust 3, black rust 1. Straw fairly strong.
- No. 60. Tall, weak ; ears light dark green ; leaves slightly drooping, broad, dark green with much bloom. Brown rust 3, yellow rust 1, black rust 1. Straw weak.

2. Intermediate in maturity.

- No. 61. Tall ; ears light green ; leaves erect, dark green with much bloom. Brown rust 2, yellow rust 1, black rust 1. Straw fairly strong.
- No. 62. Tall ; ears light green ; leaves erect, dark bluish green with much bloom. Brown rust 3, yellow rust 1, black rust 2. Straw fairly strong.
- No. 63. Tall, vigorous ; ears very light green ; leaves erect, broad, light green with moderate bloom. Brown rust 2, yellow rust 1, black rust 2. Straw fairly strong.
- No. 64. Intermediate in height ; ears dark green ; leaves erect, dark green with much bloom. Brown rust 2, yellow rust 1, black rust 1. Straw weak.

No. 65. Tall (taller than No. 64), weak; ears dark green; leaves erect, dark green (lighter than Nos. 64 and 66) with much bloom. Brown rust 2, yellow rust 1, black rust 1. Straw weak.

No. 66. Intermediate in height, weak; ears dark green; leaves erect, dark green with much bloom. Brown rust 2, yellow rust 2, black rust 2. Straw weak.

Nos. 64, 65 and 66 closely resemble each other in the field. No. 65 is taller and has lighter foliage than No. 64. No. 66 is shorter and more susceptible to yellow and black rusts than the other two.

No. 67. Intermediate in height, vigorous; ears very light green; leaves erect, dark green with slight bloom. Brown rust 1, yellow rust 2, black rust 4. Straw fairly strong.

### 3. Late.

No. 68. Intermediate in height; ears dark green; leaves erect, dark green with slight bloom. Brown rust 1, yellow rust 1, black rust 2. Straw fairly strong.

No. 69. Intermediate in height; ears dark green (lighter than No. 68); leaves erect, dark green with slight bloom. Brown rust 2, yellow rust 2, black rust 3. Straw fairly strong.

Nos. 68 and 69 are nearly alike in the field and only differ in the colour of the ears and in rust resistance.

No. 70. Intermediate in height, strong; ears somewhat light dull green; leaves somewhat drooping, dark green. Brown rust 1, black rust 2. Straw weak.

No. 71. Tall, weak; ears dark green (darker than No. 69); leaves erect, dark bluish green with much bloom. Brown rust 2, yellow rust 1, black rust 2. Straw weak.

### var. *ferrugineum* Al.

Ears bearded, glumes smooth red, grain red.

This variety comprises the following nine agricultural types which separate into four groups according to the time of maturity. The observations on the incidence of rust were made in 1915 when the conditions were favourable for yellow rust.

#### 1. Early.

No. 72. Short; ears dark green; leaves somewhat drooping, dark green with a moderate amount of bloom. Brown rust 4, yellow rust 2, black rust 2. Straw weak.

- No. 73. Intermediate in height ; ears light dull green ; leaves somewhat erect, light dull green. Brown rust 4, yellow rust 2, black rust 2. Straw very weak.
- No. 74. Tall, maturing later than Nos. 72 and 73 ; ears light bright green ; leaves erect, light bright green. Brown rust 2, yellow rust 1, black rust 3. Straw weak.
2. Intermediate in time of maturity.
- No. 75. Intermediate in height, weak ; ears light bright green ; leaves erect, light bright green with little bloom. Brown rust 3, yellow rust 1, black rust 3. Straw fairly strong.
- No. 75 ripens later and there is less bloom on the leaves than in Nos. 76 and 77.
- No. 76. Intermediate in height, vigorous ; ears light green ; leaves erect, somewhat light green with well developed bloom. Brown rust 2, yellow rust 1, black rust 2. Straw fairly strong.
- No. 77. Intermediate in height, vigorous ; ears light green (lighter than No. 76) ; leaves erect, somewhat light green with a moderate amount of bloom. Brown rust 1, yellow rust 1, black rust 2. Straw somewhat weak.
3. Late.
- No. 78. Short, weak ; ears somewhat light green ; leaves erect, dark green with slight bloom. Brown rust 3, yellow rust 3, black rust 3. Straw weak.
- No. 79. Intermediate in height, weak ; ears dark green ; leaves erect, somewhat dark green with slight bloom. Brown rust 3, yellow rust 3, black rust 2. Straw very weak.
4. Very late.
- No. 80. Intermediate in height, erect ; ears light bluish green ; leaves erect, light green with moderate bloom. Brown rust 2, yellow rust 1, black rust 3. Straw weak.

*var. nigricans.*

Ears bearded, glumes smooth, black on a white ground, awns black, grain red.

This new variety comprises twenty agricultural types which fall into four classes according to the time of maturity. Most of the types are characterized by a high degree of rust-resistance while Nos. 87, 89, 94, 95 and 98 are noteworthy in this respect. The observations on which the classification is based were made in 1916.



## 1. Very early.

No. 81. Short ; ears dull light green ; leaves erect, broad, dark green.

Brown rust 0, black rust 1. Straw very weak.

No. 82. Intermediate in height ; ears dull light green ; leaves erect, somewhat light green. Brown rust 0, black rust 1. Straw very weak.

No. 83. Intermediate in height ; ears dark green ; leaves drooping, light green. Brown rust 1, black rust 1. Straw very weak.

## 2. Early.

No. 84. Tall ; ears dull light green ; leaves erect, light green. Brown rust 0, black rust 1. Straw somewhat weak.

No. 85. Tall ; ears dull dark green ; leaves erect, dark green (darker than No. 86). Brown rust 0, black rust 1. Straw somewhat weak.

No. 86. Intermediate in height ; ears dull dark green ; leaves erect, dark green. Brown rust 0, black rust 1. Straw very weak.

Nos. 85 and 86 are nearly alike in the field and differ only in height, in the set of leaves, in the tone of colour of the ears and in strength of straw.

No. 87. Intermediate in height, fairly strong ; ears dull light green ; leaves erect, somewhat light green. Brown rust very slight, black rust very slight. Straw strong.

No. 88. Intermediate in height, fairly strong ; ears dull dark green, leaves erect, very dark green. Brown rust 0, black rust 1. Straw somewhat weak.

No. 89. Intermediate in height, fairly strong ; ears bright light green ; leaves erect, somewhat light green. Brown rust 0, black rust very slight. Straw fairly strong.

## 3. Intermediate in time of maturity.

No. 90. Intermediate in height ; ears bright dark green ; leaves erect, dark green. Brown rust 0, black rust 1. Straw somewhat weak.

No. 91. Tall ; ears somewhat bright dark green ; leaves erect, rather light green. Brown rust 0, black rust 1. Straw weak.

No. 92. Tall ; ears dull dark green ; leaves dark green. Brown rust 0, black rust 1. Straw weak.

No. 93. Intermediate in height, fairly strong ; ears dull dark green ; leaves erect, dark green. Brown rust 0, black rust 1. Straw strong.

- Nos. 90, 91, 92 and 93 closely resemble one another in the field. No. 91 is the earliest, No. 93 the latest. No. 90 has bright ears, No. 91 somewhat bright ears while the other two have ears of a dull tone.
4. Very late.
- No. 94. Intermediate in height, strong; ears dull dark green; leaves erect, very dark green. Brown rust 0, black rust very slight. Straw strong.
- No. 95. Intermediate in height, strong, earlier than No. 94; ears dark green (brighter than No. 94). Brown rust 0, black rust very slight. Straw strong.
- No. 96. Intermediate in height, strong; ears somewhat bright dark green; leaves erect, somewhat light green. Brown rust 0, black rust 1. Straw fairly strong.
- No. 97. Tall, weak; ears dull dark green; leaves erect, somewhat light green. Brown rust very slight, black rust 2. Straw weak.
- No. 98. Intermediate in height (shorter and earlier than No. 94), strong; ears dull dark green; leaves erect, dark green. Brown rust 0, black rust very slight. Straw fairly strong.
- No. 99. Tall; ears dull dark green; leaves erect, dark green. Brown rust 0, black rust 1. Straw fairly strong.
- No. 100. Tall, fairly strong, very late; ears dull dark green; leaves erect, dark green. Brown rust 0, black rust 1. Straw strong.

*var. indicum.*

Ears bearded, glumes smooth black on a red ground, awns black, grain white.

This new variety comprises nine agricultural types which fall into three groups according to time of maturity. All (particularly No. 109) exhibit a considerable degree of resistance to rust. The observations on which the classification was drawn up were made in 1916.

1. Very early.
- No. 101. Short, strong; ears dull light green; leaves erect, light green. Brown rust 0, black rust 1. Straw somewhat weak.
- No. 102. Short, strong; ears light green; leaves erect, dark green. Brown rust 1, black rust 1. Straw strong.
2. Early.
- No. 103. Intermediate in height, strong; ears dull dark green; leaves erect, dark green. Brown rust 1, black rust 1. Straw somewhat weak.

- No. 104. Intermediate in height, strong ; ears somewhat light green ; leaves erect, somewhat light green. Brown rust 1, black rust 1. Straw weak.
- No. 105. Short, weak ; ears very light dull green ; leaves erect, dark green. Brown rust 1, black rust 2. Straw weak.
- No. 106. Short, strong ; ears very light green (brighter than No. 105) ; leaves erect, dark green. Brown rust 0, black rust 2. Straw weak.
3. Late.
- No. 107. Intermediate in height, strong ; ears light bright green ; leaves erect, somewhat light green. Brown rust 1, black rust 2. Straw strong. The earliest type of the late group.
- No. 108. Intermediate in height, strong ; ears light green ripening to a dull tone ; leaves erect, dark green. Brown rust 0, black rust 1. Straw strong.
- No. 109. Intermediate in height, strong ; ears light bright green ; leaves erect, light green. Brown rust 0, black rust very slight. Straw strong.

*var. bengalensis.*

Ears bearded, glumes smooth, black on a red ground, awns black, grain red.

This new variety consists of twelve agricultural types which fall into three classes according to the time of maturity. The observations on which the classification was drawn up were made in 1915.

1. Very early.

- No. 110. Short, vigorous ; ears light green with moderate bloom ; leaves erect, light green. Brown rust 1, yellow rust 1, black rust 2. Straw fairly strong.

2. Early.

- No. 111. Intermediate in height, weak ; ears dark green with moderate bloom ; leaves broad, somewhat drooping, dark green. Brown rust 2, yellow rust 1. Straw fairly strong.
- No. 112. Intermediate in height, vigorous ; ears light bluish green with moderate bloom ; leaves somewhat drooping, light green. Brown rust 1, yellow rust 1, black rust 1. Straw weak.
- No. 113. Intermediate in height ; ears somewhat light green (darker than Nos. 112 and 114) with much bloom ; leaves somewhat drooping, light green. Brown rust 1, yellow rust 1, black rust 1. Straw weak.

No. 114. Tall, vigorous ; ears erect, light green with moderate bloom. Brown rust 1, yellow rust 1, black rust 1. Straw fairly strong. Nos. 112 and 114 are nearly alike in the field and only differ in height, in the set of the leaves and in standing power.

3. Late.

No. 115. Intermediate in height, vigorous ; ears rather dark green with much bloom ; leaves erect, dark green. Brown rust 2, yellow rust 1, black rust 1. Straw weak.

No. 116. Intermediate in height, vigorous ; ears rather dark green with much bloom ; leaves slightly drooping, dark green. Brown rust 3, yellow rust 1, black rust 1. Straw weak.

Nos. 115 and 116 closely resemble each other in the field and only differ in resistance to brown rust and in the set of the leaves.

No. 117. Tall ; ears somewhat dark green (lighter than Nos. 118 and 119) with much bloom ; leaves slightly drooping, dark green (lighter than Nos. 118 and 119). Brown rust 2, yellow rust 1, black rust 2. Straw weak.

No. 118. Tall, rather weak ; ears somewhat dark green with much bloom (more than No. 119) ; leaves erect, broad (broader than No. 119), dark green. Brown rust 2, yellow rust 1, black rust 1. Straw weak.

No. 119. Tall, weak ; ears rather dark green with moderate bloom ; leaves erect, dark green. Brown rust 3, yellow rust 1, black rust 2. Straw weak.

No. 120. Intermediate in height, weak ; ears rather dark green with much bloom ; leaves slightly drooping, dark green. Brown rust 1, yellow rust 1, black rust 1. Straw weak. (No. 120 is earlier than No. 121.)

No. 121. Intermediate in height, weak ; ears rather dark green with very much bloom ; leaves erect, dark green. Brown rust 1, yellow rust 1, black rust 1. Straw very weak.

var. *meridionale* Keke.

Ears bearded, glumes felted white, grain white.

This variety is represented by a single agricultural type which is exceedingly susceptible to black rust.

No. 122. Early, intermediate in height, strong ; ears dull dark green ; leaves erect, very dark green. Brown rust 1, black rust 4. Straw weak.



